но въ ней, мнѣ кажется, уже ясно выражается примѣнимость выставляемаго мною начала ко всей совокупности элементовъ, пай которыхъ извѣстенъ съ достовѣрностію. На этотъ разъ я и желалъ преимущественно найдти общую систему элементовъ. Вотъ этотъ опытъ:

			Ti=50	Zr=90	?=180.
			V=51	Nb=94	Ta=182.
			Cr=52	Mo=96	W=186.
			Mn=55	Rh=104,4	Pt=197,4
			Fe=56	Ru=104,4	Ir=198.
			Ni=Co=59	Pl=106,6,	Os=199.
H=1			Cu=63,4	Ag=108	Hg=200.
	Be=9,4	Mg=24	Zn=65,2	Cd=112	
	B=11	Al=27,4	?=68	Ur=116	Au=197?
	C=12	Si=28	?=70	Su=118	
	N=14	P=31	As=75	Sb=122	Bi=210
	O=16	S=32	Se=79,4	Te=128?	
	F=19	Cl=35,5	Br=80	I=127	
Li=7	Na=23	K=39	Rb=85,4	Cs=133	Tl=204
		Ca=40	Sr=87,6	Ba=137	Pb=207.
		?=45	Ce=92		
		?Er=56	La=94		
		?Yt=60	Di=95		
		?In=75,6	Th=118?		

а потому приходится въ разныхъ рядахъ имѣть различное измѣненіе разностей, чего нѣтъ въ главныхъ числахъ предлагаемой таблицы. Или же придется предполагать при составленіи системы очень много недостающихъ членовъ. То и другое мало выгодно. Мнѣ кажется притомъ, наиболѣе естественнымъ составить

Ch 5 Periodic Law

Assembly of 1st Periodic Table (New way to determine atomic Mass)
↳ Meeting in 1860 to try and determine if there was a correlation b/tween Atomic Mass and other elemental properties

Mendeleev - writing a textbook -
Arranged Known elements based on their atomic masses and properties

He saw that the elements had repeating patterns at regular intervals (periods)

Published 1st Table in 1869

His table was reverse from what it is now.
↳ Periods Vertical
Groups Horizontal

He made successful Predictions about their properties by arrangements

Q's 1 why could elements be arranged by atomic mass but some could not (I, Te)
predicts Sc, Ga, Ge

2. What was reason for periodicity

Henry Moseley (1911) 40 years later

Answered Q1 (why elements Not Arranged by A mass)

↳ Mosely saw Nucleus + charge increased by 1 unit from 1element to the next as they were arranged in the table

↳ Led to the fact that Atom # not Mass is how the periodic table should be arranged.

↳ Allowed for change of Arrangement w/ I + Te based on Atomic #

Lead to Statement

Periodic Law - physical + chemical props of elements are perodic functions of their atomic #.

As elements are arranged by perodic ↑ Atom # elements w/ similar props recur @ regular intervals.

Modern Periodic Table - arrange elements so ones w/similar props fall in same columns (Groups)

Final Additions - Noble Gases

Lanthanides - rare earth metals

Actinides - 90-103

Periodicity - A # increases by 8, 8, 18, 18, 32

Period ... Period 7

Q1, 2

5.2 Groups, Periods, Blocks of Table

↳ e^- configs can be used to explain reactivity

Outermost shell e^- (valence e^-) play role in reactivity

Most Elements in Groups have identical e^- configs

Outline Trend in table

Can find what period an element is based on highest filled E level

Ex As [Ar] $3d^{10}\,4s^2\,\underline{4p}^3$ 4th period

Divide table into 4 blocks s, d, p, f

S block elements (Group 1+2)

Group 1 always s^1 (ns^1)

Group 2 " s^2 (ns^2)

Group 1 alkali metals - combine vigorously w/ many nonmetals

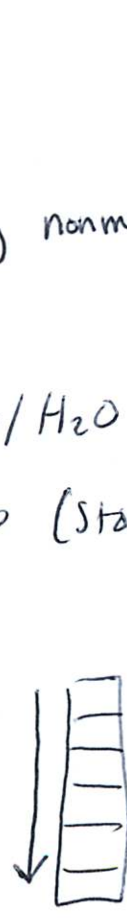
↳ very reactive b/c s^1 e^-

Not found free in Nature react w/ H_2O produce (aq) + H_2 gas Boom

Alkalis can dissolve fats produce soap (Stored in kerosene)

Silvery appearance, cut w a knife

Melt @ temps lower than H_2O BP MT



↓ down group MT ↓

Uses Na - heat transfer

Cs photoelectric effect

Gr 2 Alkaline earth Metals ns^2

~~have high~~ are harder, stronger, denser, higher MT than Gr 1

Less Reactive than Gr 1 but too reactive to exist in nature

Uses of Alkaline Earth Metals

Ca → materials of Earth's crust $CaCO_3$

Mg → $MgCO_3$ → Sea water | Also used to make

~~Be~~ → very rare

Ra → radioactive, rare

Sr → in fireworks (Flame Test)

H + He → clear colorless gases ns^1 + ns^2 respectively)
↓ only Gr 1 B/c ns^1
↳ Gr 18 b/c stable

d Block $(n-1)d^x ns^2$ (couple exceptions)

Transition Elements - all metals w/ appropriate metallic properties

higher MT, denser, harder than S block (except Hg)

Less reactive Some found freely in nature Pt, Au

Iron most important → make Steel

W - highest MT used for filaments in Bulbs

p Block elements $ns^2 np^x$

Trick For all p block elements # of valence e^- = Group # − 10

Props of p-block vary widely nonmetals, metalloid, metals all exist here.

Gr 17 − halogens − very reactive nonmetals → p^5 } make octet
↳ react w/ metals form salts s^1
Ex NaCl

At room temp F, Cl gas Br liq I solid

Gr 18 − Noble gases − ~~[illegible]~~ Nonreactive
↳ take advantage in many ways. → used in containers when something would react w/ air

Metalloids − Brittle solids, semiconductive

Metals − harder + ~~softer~~ denser than ns^2 metals
~~[illegible]~~ Not as much as d-Blocks.
Only in nature as compounds
Al is essential in lightweight alloys.

f-Block – all shiny reactive metals } lathonides
↳ Colors in TV tubes.

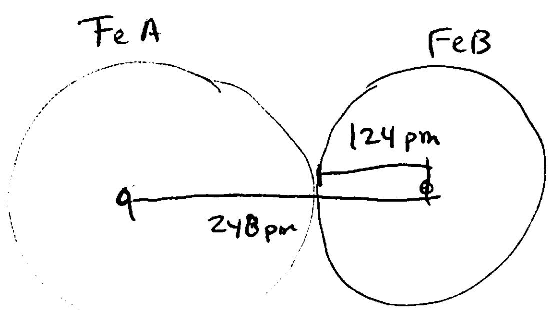
Actinides – Unstable + Radioactive Some Made in Lab

Q 2+3+5,6

e^- config Periodic Props.

Atomic Radii – e^- occupy a large, ~~as~~ undefined distance away from nucleus. -Boundary's are very fuzzy

Makes it hard to determine size of ~~nucle~~ atom that is alone
Therefore radii is measured for 2 adj atoms



Atomic radii - half the distance between nuclei of atoms joined in a solid

Period Trends – Atomic radii decrease across a period B/c increasing + charge of nucleus Brings ~~atoms~~ e^- closer in.

Group Trends – main groups (s+p) radii increase ↓ the group

Descrepancy Al → Ga Gr 13 B/c D-Block switch
↳ higher nuclear charge.

Periodic Table of Atomic Radii

Key: Atomic Symbol — C; Atomic Number — 6; Atomic Radius (pm) — 77

Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9	Group 10	Group 11	Group 12	Group 13	Group 14	Group 15	Group 16	Group 17	Group 18
H 1 37																	He 2 [illegible]
Li 3 152	Be 4 111											B 5 79	C 6 77	N 7 74	O 8 73	F 9 71	Ne 10 6[illegible]
Na 11 186	Mg 12 160											Al 13 143	Si 14 117	P 15 116	S 16 102	Cl 17 99	Ar 18 9[illegible]
K 19 227	Ca 20 197	Sc 21 161	Ti 22 145	V 23 131	Cr 24 125	Mn 25 129	Fe 26 124	Co 27 125	Ni 28 125	Cu 29 128	Zn 30 133	Ga 31 122	Ge 32 122	As 33 121	Se 34 116	Br 35 114	Kr 36 11[illegible]
Rb 37 248	Sr 38 215	Y 39 178	Zr 40 159	Nb 41 143	Mo 42 136	Tc 43 135	Ru 44 133	Rh 45 135	Pd 46 138	Ag 47 145	Cd 48 149	In 49 162	Sn 50 141	Sb 51 141	Te 52 130	I 53 133	Xe 54 13[illegible]
Cs 55 265	Ba 56 217	La 57 187	Hf 72 156	Ta 73 143	W 74 137	Re 75 137	Os 76 137	Ir 77 136	Pt 78 139	Au 79 144	Hg 80 150	Tl 81 171	Pb 82 175	Bi 83 155	Po 84 140	At 85 140	Rn 86 14[illegible]
Fr 87 270	Ra 88 220	Ac 89 200	Unq 104	Unp 105	Unh 106	Uns 107	Uno 108	Une 109									

Figure 5-12 Atomic radii decrease from left to right across a period and increase down a group.

Lanthanide Series

Ce 58	Pr 59	Nd 60	Pm 61	Sm 62	Eu 63	Gd 64	Tb 65	Dy 66	Ho 67	Er 68	Tm 69	Yb 70	Lu 71
183	182	181	181	180	199	179	176	175	174	173	173	194	1[illegible]2

Th 90	Pa 91	U 92	Np 93	Pu 94	Am 95	Cm 96	Bk 97	Cf 98	Es 99	Fm 100	Md 101	No 102	Lr 103
180	161	139											

Actinide Series

Sample Problem 5.5

(a) Among the elements magnesium (Mg), chlorine (Cl), sodium (Na), and phosphorus (P), which has the largest atomic radius? Explain in terms of Periodic Table trends.
(b) Among the elements calcium (Ca), beryllium (Be), barium (Ba), and strontium (Sr), which has the largest atomic radius? Explain in terms of Periodic Table trends.

Solution

(a) These elements are all in the third period. Of the four, sodium has the lowest atomic number and is the first element in the period. Sodium has the largest atomic radius, as expected because atomic radii decrease across the period. *(b)* These elements are all in Group 2. Of the four, barium has the highest atomic number and is furthest down the group. From its position, we would expect it to have the largest atomic radius, and this is correct.

Practice Problems

1. Among the elements Li, O, C, F, and N, identify the one with the: *(a)* largest atomic radius *(Ans.)* Li *(b)* smallest atomic radius. *(Ans.)* F
2. Among the elements Br, At, F, I, and Cl, identify the one with the: *(a)* smallest atomic radius *(Ans.)* F *(b)* largest atomic radius. *(Ans.)* At

First Ionization Energies
kJ/mol

Key	
6	Atomic Number
C	Symbol
1086	First Ionization Energy

Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9	Group 10	Group 11	Group 12	Group 13	Group 14	Group 15	Group 16	Group 17	Group 18
1 **H** 1312																	2 **He** 2372
3 **Li** 520	4 **Be** 900											5 **B** 801	6 **C** 1086	7 **N** 1402	8 **O** 1314	9 **F** 1681	10 **Ne** 2081
11 **Na** 496	12 **Mg** 738											13 **Al** 578	14 **Si** 787	15 **P** 1012	16 **S** 1000	17 **Cl** 1251	18 **Ar** 1521
19 **K** 419	20 **Ca** 590	21 **Sc** 631	22 **Ti** 658	23 **V** 650	24 **Cr** 653	25 **Mn** 717	26 **Fe** 759	27 **Co** 758	28 **Ni** 737	29 **Cu** 746	30 **Zn** 906	31 **Ga** 579	32 **Ge** 762	33 **As** 944	34 **Se** 941	35 **Br** 1140	36 **Kr** 1351
37 **Rb** 403	38 **Sr** 550	39 **Y** 616	40 **Zr** 660	41 **Nb** 664	42 **Mo** 685	43 **Tc** 702	44 **Ru** 711	45 **Rh** 720	46 **Pd** 805	47 **Ag** 731	48 **Cd** 868	49 **In** 558	50 **Sn** 709	51 **Sb** 832	52 **Te** 869	53 **I** 1008	54 **Xe** 1170
55 **Cs** 376	56 **Ba** 503	57 **La** 538	72 **Hf** 654	73 **Ta** 761	74 **W** 770	75 **Re** 760	76 **Os** 840	77 **Ir** 880	78 **Pt** 870	79 **Au** 890	80 **Hg** 1007	81 **Tl** 589	82 **Pb** 716	83 **Bi** 703	84 **Po** 812	85 **At** –	86 **Rn** 1038
87 **Fr** –	88 **Ra** 509	89 **Ac** 490	104 **Unq**	105 **Unp**	106 **Unh**	107 **Uns**	108 **Uno**	109 **Une**									

Lanthanide Series

58 **Ce** 528	59 **Pr** 523	60 **Nd** 530	61 **Pm** 536	62 **Sm** 543	63 **Eu** 547	64 **Gd** 592	65 **Tb** 564	66 **Dy** 572	67 **Ho** 581	68 **Er** 589	69 **Tm** 597	70 **Yb** 603	71 **Lu** 523
90 **Th** 590	91 **Pa** 570	92 **U** 590	93 **Np**	94 **Pu**	95 **Am**	96 **Cm**	97 **Bk**	98 **Cf**	99 **Es**	100 **Fm**	101 **Md**	102 **No**	103 **Lr**

Actinide Series

Ionization Energy

A = atom

$$A + \text{Energy} \rightarrow A^+ + e^-$$

↑ ion -

ion - atom w/ positive or neg charge

Ionization - any process that results in an ion

1st Ionization E. E it takes to remove one e^- from an element
↳ in KJ/mol

☆ Q? - IE 500 KJ/mol for Li How much E to remove one e^- from 1 Li atom

$1 \text{ atom Li} \times \frac{1 \text{ mol}}{6 \times 10^{23} \text{ atoms}}$ $1.66 \times 10^{-24} \text{ mol} \times 500 \frac{KJ}{mol} = 8.3 \times 10^{-22} KJ$

Period Trends

The elements in Gr 1 have lowest IE Gr 18 highest

☆ ↳ Remember why Gr 1 are so reactive B/c Low IE

The Noble Gases are not reactive @ all so high IE

Across a Period IE ↑ b/c nuclear charge ↑ (atomic radii ↓)

TABLE 5-4 FIRST FIVE IONIZATION ENERGIES (IN KJ/MOL) FOR ELEMENTS OF PERIODS 1–3

	Period 1		Period 2							
	H	He	Li	Be	B	C	N	O	F	Ne
I	1312	[redacted]	520	900	801	1086	1402	1314	1681	2081
II		5250	[redacted]	1757	2427	2353	2856	3388	3374	3952
III			11 815	[redacted]	3660	4621	4578	5300	6050	6122
IV				21 007	[redacted]	6223	7475	7469	8408	9370
V					32 827	[redacted]	9445	10 990	11 023	12 178

	Period 3							
	Na	Mg	Al	Si	P	S	Cl	Ar
I	496	738	578	787	1012	1000	1251	1521
II	[redacted]	1451	1817	1577	1903	2251	2297	2666
III	6912	[redacted]	2745	3232	2912	3361	3822	3931
IV	9544	10 540	[redacted]	4356	4957	4564	5158	5771
V	13 353	13 628	14 831	[redacted]	6274	7031	6540	7238

IE con't ~~Period IE~~ Group Trends

IE Decreases down the groups

↳ B/c the e^- in higher E levels are easier removed b/c farther from nucleus.

also there are more e^- inside to sheild them from the nucleus's + charge

2nd + 3rd IE are even higher than 1st

If you remove an e^- and it gets config of a noble gas The IE is even higher. B/c config is so stable

↳ ~~Dec~~ 2nd Ionic Radii

Electron Affinity

Neutal atoms can acquire e^-

↳ E change that occurs when atoms takes on e^-

Exothermic - $A + e^- \rightarrow A^- + E$ Q of E lost is rep by -#

either

Endothermic - $A + e^- + E \rightarrow A^-$

Period trends - Halogens gain e^- the most easily high neg # (why reactive) → get full outer shell

Gr 2 + Gr 18 ~~easy~~ + e^-A b/c full outer shell

N = 0 b/c 1 e^- in each orbital going to 2nd round

Electron Affinities
kJ/mol

6 — Atomic Number
C — Symbol
−123 — Electron Affinity

Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9	Group 10	Group 11	Group 12	Group 13	Group 14	Group 15	Group 16	Group 17	Group 18
1 **H** -73																	2 **He** (21)
3 **Li** -60	4 **Be** (240)											5 **B** -83	6 **C** -123	7 **N** 0	8 **O** -141	9 **F** -322	10 **Ne** (29)
11 **Na** -53	12 **Mg** (230)											13 **Al** (-50)	14 **Si** -120	15 **P** -74	16 **S** -200	17 **Cl** -349	18 **Ar** (35)
19 **K** -48	20 **Ca** (156)	21 **Sc** —	22 **Ti** -38	23 **V** -90	24 **Cr** -64	25 **Mn** —	26 **Fe** -56	27 **Co** -90	28 **Ni** -123	29 **Cu** -123	30 **Zn** —	31 **Ga** (-36)	32 **Ge** -116	33 **As** -77	34 **Se** -195	35 **Br** -325	36 **Kr** (39)
37 **Rb** -47	38 **Sr** (168)	39 **Y** —	40 **Zr** —	41 **Nb** —	42 **Mo** -96	43 **Tc** —	44 **Ru** —	45 **Rh** —	46 **Pd** —	47 **Ag** -126	48 **Cd** —	49 **In** -34	50 **Sn** -121	51 **Sb** -101	52 **Te** -183	53 **I** -295	54 **Xe** (41)
55 **Cs** -46	56 **Ba** (52)	57 **La** —	72 **Hf** —	73 **Ta** -80	74 **W** -50	75 **Re** -14	76 **Os** —	77 **Ir** —	78 **Pt** -205	79 **Au** -223	80 **Hg** —	81 **Tl** -50	82 **Pb** -101	83 **Bi** -101	84 **Po** (-170)	85 **At** (-270)	86 **Rn** (41)
87 **Fr** (-44)	88 **Ra** —	89 **Ac** —	104 **Unq**	105 **Unp**	106 **Unh**	107 **Uns**	108 **Uno**	109 **Une**									

Values in parentheses are calculated; values not in parentheses are experimental.

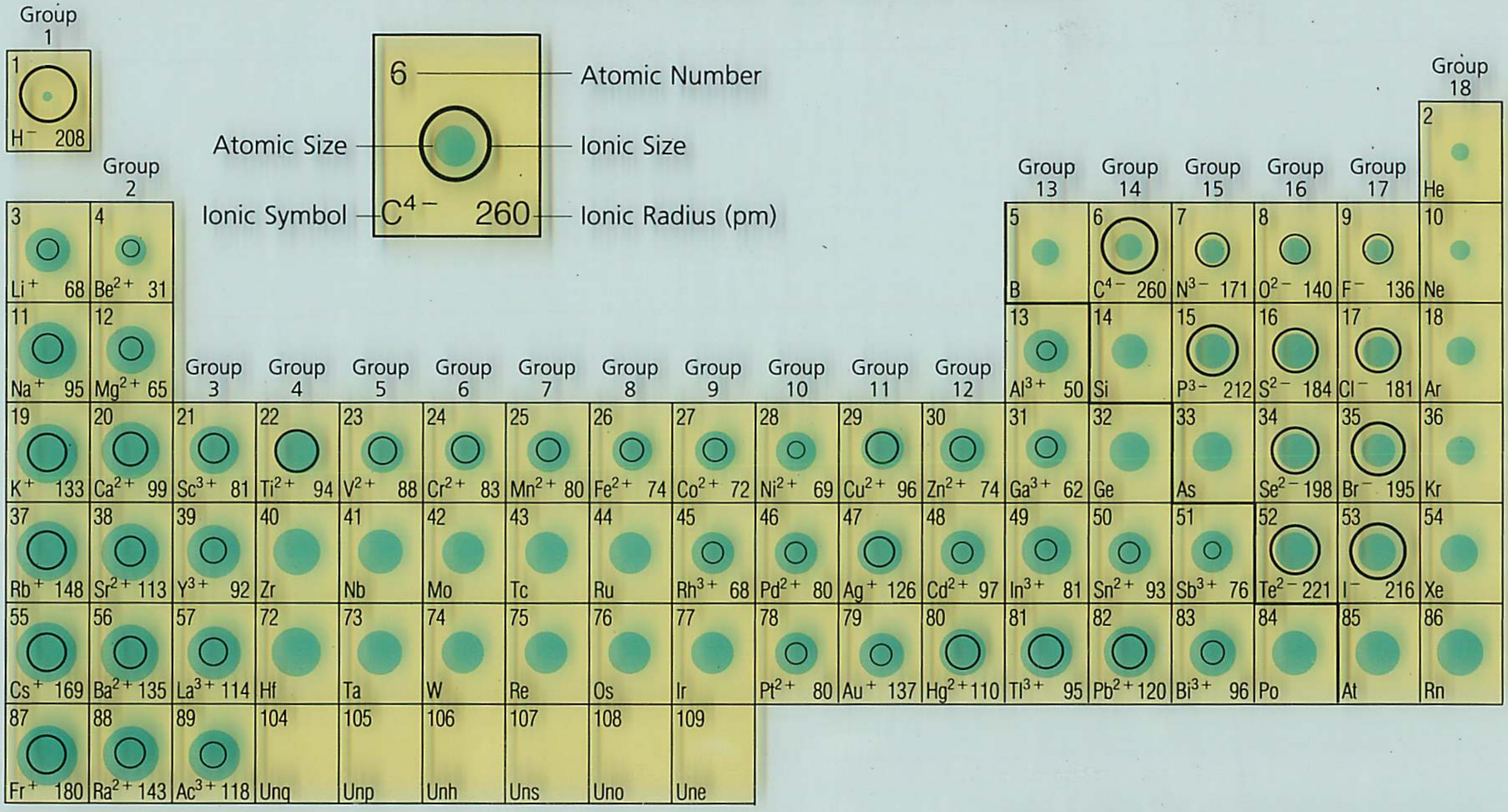
Electron Affinities
kJ/mol

Key:
- Atomic Number — 6
- Symbol — C
- Electron Affinity — -123

Period	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9	Group 10	Group 11	Group 12	Group 13	Group 14	Group 15	Group 16	Group 17	Group 18
1	1 H -73																	2 He (21)
2	3 Li -60	4 Be (240)											5 B -88	6 C -123	7 N 0	8 O -141	9 F -322	10 Ne (29)
3	11 Na -53	12 Mg (230)											13 Al (-50)	14 Si -120	15 P -74	16 S -200	17 Cl -349	18 Ar (35)
4	19 K -48	20 Ca (156)	21 Sc —	22 Ti -38	23 V -90	24 Cr -64	25 Mn —	26 Fe -56	27 Co -90	28 Ni -123	29 Cu -123	30 Zn —	31 Ga (-36)	32 Ge -116	33 As -77	34 Se -195	35 Br -325	36 Kr (39)
5	37 Rb -47	38 Sr (168)	39 Y —	40 Zr —	41 Nb —	42 Mo -96	43 Tc —	44 Ru —	45 Rh —	46 Pd —	47 Ag -126	48 Cd —	49 In -34	50 Sn -121	51 Sb -101	52 Te -183	53 I -295	54 Xe (41)
6	55 Cs -46	56 Ba (52)	57 La —	72 Hf —	73 Ta -80	74 W -50	75 Re -14	76 Os —	77 Ir —	78 Pt -205	79 Au -223	80 Hg —	81 Tl -50	82 Pb -101	83 Bi -101	84 Po (-170)	85 At (-270)	86 Rn (41)
7	87 Fr (-44)	88 Ra —	89 Ac —	104 Unq	105 Unp	106 Unh	107 Uns	108 Uno	109 Une									

Values in parentheses are calculated; values not in parentheses are experimental.

Periodic Table of Ionic Radii



Bigger AR, IE, (IR) e^-A

H or Rb   B or O

K or Br   Na or I

Zn or Ga   Ag or Cd

Hg or Ba   F or Cl

Pb or Rn   He or Ar

Ca^{2+} or Mg^{2+} Na^+ or Mg^{2+}

O^{2-} or F^- Cl^- or Br^-

Periodic Table of the Electronegativities

Key	
6	Atomic Number
C	Symbol
2.5	Electronegativity

Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9	Group 10	Group 11	Group 12	Group 13	Group 14	Group 15	Group 16	Group 17	Group 18
1 **H** 2.1																	2 **He**
3 **Li** 1.0	4 **Be** 1.5											5 **B** 2.0	6 **C** 2.5	7 **N** 3.0	8 **O** 3.5	9 **F** 4.0	10 **Ne**
11 **Na** 0.9	12 **Mg** 1.2											13 **Al** 1.5	14 **Si** 1.8	15 **P** 2.1	16 **S** 2.5	17 **Cl** 3.0	18 **Ar**
19 **K** 0.8	20 **Ca** 1.0	21 **Sc** 1.3	22 **Ti** 1.5	23 **V** 1.6	24 **Cr** 1.6	25 **Mn** 1.5	26 **Fe** 1.8	27 **Co** 1.8	28 **Ni** 1.8	29 **Cu** 1.9	30 **Zn** 1.6	31 **Ga** 1.6	32 **Ge** 1.8	33 **As** 2.0	34 **Se** 2.4	35 **Br** 2.8	36 **Kr** 3.0
37 **Rb** 0.8	38 **Sr** 1.0	39 **Y** 1.2	40 **Zr** 1.4	41 **Nb** 1.6	42 **Mo** 1.8	43 **Tc** 1.9	44 **Ru** 2.2	45 **Rh** 2.2	46 **Pd** 2.2	47 **Ag** 1.9	48 **Cd** 1.7	49 **In** 1.7	50 **Sn** 1.8	51 **Sb** 1.9	52 **Te** 2.1	53 **I** 2.5	54 **Xe** 2.6
55 **Cs** 0.7	56 **Ba** 0.9	57 **La** 1.1	72 **Hf** 1.3	73 **Ta** 1.5	74 **W** 1.7	75 **Re** 1.9	76 **Os** 2.2	77 **Ir** 2.2	78 **Pt** 2.2	79 **Au** 2.4	80 **Hg** 1.9	81 **Tl** 1.8	82 **Pb** 1.8	83 **Bi** 1.9	84 **Po** 2.0	85 **At** 2.2	86 **Rn** 2.4
87 **Fr** 0.7	88 **Ra** 0.9	89 **Ac** 1.1	104 **Unq**	105 **Unp**	106 **Unh**	107 **Uns**	108 **Uno**	109 **Une**									

Lanthanide Series

58 **Ce** 1.1	59 **Pr** 1.1	60 **Nd** 1.1	61 **Pm** 1.1	62 **Sm** 1.1	63 **Eu** 1.1	64 **Gd** 1.1	65 **Tb** 1.1	66 **Dy** 1.1	67 **Ho** 1.1	68 **Er** 1.1	69 **Tm** 1.1	70 **Yb** 1.1	71 **Lu** 1.2

Actinide Series

90 **Th** 1.3	91 **Pa** 1.5	92 **U** 1.7	93 **Np** 1.3	94 **Pu** 1.3	95 **Am** 1.3	96 **Cm** 1.3	97 **Bk** 1.3	98 **Cf** 1.3	99 **Es** 1.3	100 **Fm** 1.3	101 **Md** 1.3	102 **No** 1.3	103 **Lr**

Group Trends - Difficult to say if any patterns
Not easily explained
Transition Metals gets lower b/c ~~e~~ + charge shielded by nucleus so harder to add neg charge

- Ions   2nd eA - higher b/c harder to bring a e^- to already negative ion.

Do get $^{-2}$ ions b/c ions go to noble gas configuration. O^{-2} [He] $2s^2$ $2p^6$

Ionic Radii - ½ diameter between of ion in ionic compound

Cation - (+) ion → formation leads to decrease
anion - (-) ion → increase in ion size - b/c neg charges repel

Valence e^- - are the ones easily lost + shared to get bonding

talk about order that e^- are lost outside in!

Electronegativity - ~~measure~~ ability of of an atom to in a chemical compound to attract e^-

Linus Pauling - (d. 1994)
is fix in Book

F is the most electron neg - ~~the~~ scale based on F
Period increase across a period from Gr 1 → Gr 17
Group - decrease ↓ a group
b/c ~~ions~~ larger ions don't hold e^- in b/c so big.

~~Ot~~ d- + f- block elements

Atomic Radii - d- decrease across periods

Ion Formation - highest s levels removed 1st

Fe lose 2 $4s^2$ e^- → Fe^{+2}

los 3 ~~2~~ $4s^2 3d$ → Fe^{+3}

All other trends apply.

End